Economic Development and Heterogeneity in the Great Moderation among the States

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Abstract

Using state level personal income, we document the substantial heterogeneity in the magnitude and timing of the Great Moderation. Low income states experienced remarkable moderation, but some richer states experienced significant increases in volatility. Empirical analysis of the determinants of volatility demonstrates an important role for economic development. Reduction in income volatility is associated with an increase in income and the degree of diversification. Expansion of interstate banking and the size of the service sector also influenced volatility.

Key Words: Great Moderation, Economic Development, Specialization

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1 Introduction

An observed reduction in the volatility of real macro variables has come to be described as the Great Moderation. Formal statistical tests have verified the existence of a structural break around 1984 in the volatility of U.S. aggregate time series (Stock and Watson (2003)). Yet there has been some recognition that changes in volatility at the macro level can conceal important differences in volatility at the micro level, and more specifically among states, industries, firms, and households (Davis and Kahn (2008); Dynan, Elmendorf, and Sichel (2006)). Therefore, analyzing state-level data can teach us valuable lessons about the Great Moderation, which are not readily attainable by appealing to aggregate data.

State level analysis is also appealing as it allows one to study the Great Moderation while holding constant monetary and exchange rate policy, as well as a range of cultural and institutional variables. Even if one controls for such variables, there remains substantial variation across states in important economic aspects such as specialization in production, the structure of production and employment, financial regulation (Morgan, Rime, and Strahan (2004)), and the age distribution of the population (Jaimovich and Siu (2009)). All those variables can differentially impact individual states and hence contribute to asymmetries in their moderation. It is precisely this heterogeneity in the degree as well as the timing of the Great Moderation in the U.S. states that we study in this paper.

Previous papers have analyzed the moderation and its causes in the U.S. states (a non-exhaustive list includes Carlino and DeFina (1998); Carlino, DeFina, and Sill (2007); Owyang, Piger, and Wall (2005)).[1] Moreover, authors such as Stock and Watson (2003) and Dynan, Elmendorf, and Sichel (2006) have reported that employment and the GDP components in U.S. have moderated, but in different degrees and with different timing. Similarly, Benati (2008) reports heterogeneity in the degrees of moderation for the Group of Seven countries. Two novel features set our manuscript apart from those earlier contributions: 1) the use of personal income at the state level as the relevant variable; and 2) the formulation of an alternative explanation for the substantial heterogeneity found in the state moderations.

[1] State data have also been employed to study convergence of growth rates (Barro and Sala-i Martin (1992), Caselli and Coleman (2001), and Young et al. (2008)) and risk sharing across states (Asdrubali and Kim (2008); Del Negro (2002)).

To study the Great Moderation inside the U.S., we conduct a battery of regressions and tests based on McConnell and Perez-Quiros (2000) using real personal income at the state level as the object of interest. We view personal income as an informative variable to study because of its implications for growth convergence (Barro and Sala-i Martin (1992)), risk sharing (Asdrubali, Sorensen, and Yosha (1996); Athanasoulis and van Wincoop (2001); Del Negro (2002)) and consumption and welfare through the Permanent Income Hypothesis (Friedman (1957); Hall (1978); Luengo-Prado and Sorensen (2008)). Similar to aggregate data-based studies (Stock and Watson (2005); Fernandez-Villaverde and Rubio-Ramirez (2007); Justiniano and Primiceri (2008)), we document a large decline in the volatility of real personal income at the state level. However, the data also reveal substantial heterogeneity in the size of the moderation across states as well as the timing of the moderation. Indeed, whereas some states like New York actually experienced an increase in volatility, others such as South Dakota had a remarkable moderation. According to the break tests, most states started their moderation in the period $1982 - 1987$. Our empirical exercises further indicate that states with relatively low per capita incomes have benefited the most from the Great Moderation. For example, the volatility of income in Mississippi, which had the lowest per capita real income in the country in 1960, has declined by 60% (see Table 1).

The substantial heterogeneity in the Great Moderation is likely a consequence of several forces acting together. Indeed, the literature has explained the heterogeneity based on factors such as the role of banking integration (Morgan, Rime, and Strahan (2004)), differences in the manufacturing sector and state banking deregulation (Carlino, DeFina, and Sill (2007)), and monetary policy (Owyang, Piger, and Wall (2008)). Rather than investigating the plausibility of those explanations, we explore the heterogeneous moderation in the U.S. states from a developmental and diversification perspective. Our approach is motivated by two observations. First, our data reveal that relatively poorer and less developed states display the greatest degree of moderation, while the states that have experienced increases in the volatility are the relatively richer ones. Second, the findings in Barro and Sala-i Martin (1992) and Caselli and Coleman (2001) show that the relative rise in income levels in poor southern states have resulted from a structural transformation out of agriculture into industry. Our aim is to investigate the role

of structural transformation and changes in income in generating the various moderation levels among the states. The relationship between volatility and economic development is not new to our paper. In fact, it has been theoretically established by numerous studies (e.g., Greenwood and Jovanovic (1990), Saint-Paul (1992), Obstfeld (1994), and Acemoglu and Zilibotti (1997)), and have been investigated empirically in the context of cross-country studies (Koren and Tenreyro (2007)).

We empirically assess our aforementioned finding by estimating the relationship between income growth volatility and level of income and degree of specialization. The measure of specialization captures the concentration of employment in 33 sectors that are reported by the Bureau of Labor Statistics. Our results show that there is a significant non-monotonic relationship between the level of income and income growth volatility. Volatility first decreases and at later stages increases with the level of income. Moreover, the volatility significantly decreases with the level of diversification. These findings imply that as the poor states diversified their production base away from endowment sectors and as their income level increased, their income growth moderated. On the other hand, as the rich states started to specialize in high risk-high return sectors, their income growth volatility increased. This pattern is consistent the results of the structural break tests. Our results are robust to the inclusion of some of the state-level determinants of moderation that have been studied in the literature. Additionally, we find that the degree of interstate banking and the size of services and durable manufacturing sectors are significant determinants of income growth volatility.

The rest of the paper is organized as follows. Section 2 documents the Great Moderation at the state level with special emphasis on the substantial heterogeneity found in the data. In Section 3, we explore the implications of state income and development on the state moderation. Some concluding remarks are provided in the last section.

2 Great Moderation at the State Level

We begin our discussion by documenting the substantial heterogeneity found in the volatility of income for the contiguous 48 states. Our choice of personal income data as a measure of state level economic activity follows previous research such as Barro and Sala-i Martin (1992),

Carlino and Mills (1993), Quah (1996) and Athanasoulis and van Wincoop (2001). We use quarterly personal income, which is published by the Bureau of Economic Analysis for the period $1960-2001$.[2] The data are seasonally adjusted using the Census Bureau's X11 program. Volatilities are computed using annual growth rates of per capita real personal income, y_t, i.e. $\Delta y_t = \log(y_t/y_{t-4})$. We obtain real per capita personal income by deflating the personal income series by the consumer price index (source: Bureau of Labor Statistics) due to the unavailability of state level price indexes with the scope needed for our study.[3] Finally, to compute per capita figures, we divide quarterly real personal income by annual state population reported by the US Census Bureau. In results not reported here, we find that using real personal income delivers similar results, so we did not attempt to interpolate population from annual to a quarterly frequency.

2.1 A first glance at the moderation

To study the breaks in the variance of the growth in state income, we rely on the univariate method proposed by McConnell and Perez-Quiros (2000). Their approach essentially consists of splitting the sample around a given date, $\widetilde{t}$, and then fitting an AR(1) model for the growth rate of income in each subsample. Next, a structural break test is implemented on the residuals from the AR(1) processes for several splitting dates. The most likely date for the start of the moderation is the $\widetilde{t}$ whose structural break date has the highest Wald statistic (further details are presented in the appendix).

Table 1 presents 1) The nominal income in 1960 for each states in our sample, and 2) The ratio of the post- to the pre-moderation volatilities (degree of moderation) for the states as well as the nation. A star indicates that the equality of pre- and post-moderation volatilities is rejected at 5%.[4] We label *moderators* those states whose ratio of volatilities is less than

[2]The Bureau of Economic Analysis defines personal income as the sum of wage and salary disbursements, supplements to wages and salaries, proprietors' income with inventory valuation and capital consumption adjustments, rental income of persons with capital consumption adjustment, personal dividend income, personal interest income, and personal current transfer receipts, less contributions for government social insurance. See www.bea.gov for more details.

[3]This is a common practice in the literature, and a non-exhaustive list of this approach includes Asdrubali, Sorensen, and Yosha (1996), Athanasoulis and van Wincoop (2001) and Luengo-Prado and Sorensen (2008)). Two exceptions to this practice are Del Negro (2002), and Hess and Shin (1998), who are able to build state level CPI's but only for a reduced number of states and at an annual basis.

[4]The significance of the test was determined using the tables reported in Hansen (1997).

one, and their test is statistically significant. The remaining states are grouped in the category *non-moderators*.

As one may expect, the results indicate that aggregate (nationwide) personal income has become smoother over time. Indeed, the post-moderation volatility is approximately 87% of that in the pre-moderation period.[5,6] The structural break test identifies the fourth quarter of 1984 as the most likely date when aggregate personal income changed its volatility. This finding nicely accords with the dates typically reported in the literature. For example, Kim and Nelson (1999) and McConnell and Perez-Quiros (2000) estimate that the moderation started in the first quarter of 1984. Similarly, Stock and Watson (2003) find that " [our] 67% confidence interval for the break in the conditional variance of four-quarter GDP growth is 1982:4 to 1985:3."

A closer look at individual states in Table 1 reveals substantial heterogeneity in the size of the moderation as well as the break dates. Although the average ratio of volatilities is 0.86, a value close to the estimate using aggregate income data, a 90-percentile interval includes $[0.39, 1.93]$. The upper bound indeed suggests that personal income in some states did not moderate but rather became more volatile over time. Examples include Massachusetts and New York whose ratios of volatilities are 1.69 and 1.36, respectively. In the middle of the sample, we find Virginia and Texas with degrees of moderation of 0.83 and 0.86, respectively. For the five states with the greatest moderation, the ratio ranged from 0.33 to 0.48. All five had below average incomes, and they included the two poorest states in the union, Mississippi and Arkansas.

To further assess the heterogeneity in the degree of moderation, Figure 1 presents the kernel density associated with the ratios of income volatilities.[7] From this figure, it is apparent that most states did indeed moderate (a large fraction of the distribution mass lies below 1). However, the distribution's fat right tail confirms that an important fraction of the states falls in the non-moderator category. In fact, a quick look at Table 1 reveals that 17 out of 48 states are classified

[5] As in Stock and Watson (2002), we find that the variance break test for aggregate personal income is not significant even at 10%.

[6] To the observers of the Great Moderation, this decline may seem small relative to the existing evidence. For example, Stock and Watson (2003) find that GDP became 60% less volatile in the post-83 period. The smaller drop in volatility reported here is partially because personal income includes, among other things, net factor payments from the rest of the world and cash payments of dividends, which are typically highly volatile series (Bloom (2007)).

[7] The kernel density was estimated using a normal kernel smoother with 100 points spanning the entire range of the data.

as non-moderators. Furthermore, of those 17 states 10 display a statistically significant increase in their volatilities.

When we turn to the break dates, Table 1 indicates that more than half of the states started their moderations in the period $1981 - 1987$. Based on the state level observations, the average date for the start of moderation is the third quarter of 1983, which is surprisingly close to the one found using aggregate income data. Similar to the degree of moderation, there is significant variation in the starting dates of the moderation. This heterogeneity is clearly portrayed in Figure 2, which presents the kernel density for the break date as predicted by our structural change test. Once again we observe that the moderation for the majority of states started in the early 1980s. Additionally, the distribution features three small lobes: two around 1970 and the third one near 1995. These lobes suggest that some states have either a very early break (Connecticut) or a very late one (Vermont). Hall (2005), however, warns that such outliers should be treated carefully as the break test is based on very few observations for asymptotic theory to provide a reliable approximation.[8]

2.2 Closer look at the tails

To further study the degree of heterogeneity in the moderation, we now concentrate on two groups of states. The first group, *large moderators*, contains those states whose degree of moderation falls in the lowest 10% of the distribution of ratios of volatilities. Our second category, *large non-moderators*, corresponds to those states whose ratio of volatilities lies in the highest 10% of the distribution. When selecting the members of these groups, we excluded those states whose test was not statistically significant or the test predicted a break near 1967 or 1993 (see above discussion and Hall (2005)).

The *large moderators* group includes the following states: Arkansas, Mississippi, Montana, North Dakota, and South Dakota. According to the results in Table 1, our test places the break for those states around 1984; North Dakota is the earliest: fourth quarter of 1981 and Mississippi is the latest: fourth quarter of 1986. Furthermore, the volatility of those states has fallen at

[8]The structural break test is based on running regressions on two subsamples (see appendix, and McConnell and Perez-Quiros (2000)). Hence the presence of a break in 1967 or in 1995 is based on a subsample of 24 observations.

least by a factor of two, with South Dakota having the sharpest decline (67% drop) followed by Arkansas (64% drop).

To better visualize the decline in the volatilities, the upper panel of Figure 3 shows the 10-year rolling volatilities for the extreme Moderator group. The solid vertical line marks the break date as predicted by our test. Note that the smoothing of the large moderators started in the 1960s which was temporarily interrupted during the 1970s and the first part of the 1980s. Interestingly, Blanchard and Simon (2001) report a similar interruption in the moderation of U.S. aggregate variables. A closer look at the figure reveals that the Dakotas have been the largest beneficiaries from the Great Moderation. North Dakota, for example, consistently displayed a volatility around 15% prior to the 1980s. However, by the year 2001, when our sample ends, the volatility has declined to something close to 5%. We observe a similar pattern for South Dakota. Interestingly, the volatilities of the remaining states in the *large moderators* group fall below 2% by the end of 2001.

The *large non-moderators* group contains the following states: California, Massachusetts, New Jersey, New York, and Wyoming. The variance break test in Table 1 shows that the change in volatilities happened as early as the first quarter of 1972 (Wyoming) or as late as 1990 (California). A look at the rolling volatilities (second panel in Figure 3) shows that either the volatilities have been increasing over time (California, Massachusetts, and New York) or there have been multiple breaks in the series (New Jersey and Wyoming). Figure 3 also reveals that the volatility of the *large non-moderator* states has been always at or below 5%. This result suggests that these states did not benefit from the Great Moderation because they were already enjoying significantly less volatile environments. Hence there was little room for the Great Moderation to contribute to the smoothing of those states. In fact, the volatilities for these states were around 2.5% in the 1960s, which was at least half the volatility displayed by the large moderators in the same decade.

The asymmetric moderation of the U.S. states raises the question of what factors may account for it. As argued in the introduction, the literature has advanced several explanations to capture the heterogenous moderation (monetary policy, and banking deregulation).[9] In the

[9]Asdrubali, Sorensen, and Yosha (1996) argue that state level data are subject to substantial measurement errors. Hence, the heterogeneity in the moderation might just reflect asymmetries in the way the data are collected.

next section, we propose an alternative view. Our proposal is motivated by two notable features of the data in Table 1. First, except Montana all the states in the *large moderators* group were in the lowest 25 percentile of the distribution of real per capita income in 1960. Mississippi, for example, had the lowest income in the country in 1960. Furthermore, even though Mississippi was still the poorest state in the country in 2001, the ratio of its per capita real personal income to that of the richest state dropped from 0.53 in 1960 to 0.42 in 2001. Second, all the *large non-moderator* states enjoyed large real incomes, which were above the 75 percentile of the country's income in 1960. Finally, our approach is also guided by the income convergence literature. Caselli and Coleman (2001), for example, establish both empirically and theoretically that income in southern poor states rose due to a structural shift away from agriculture into more capital-intensive enterprises. Indeed, our measures of diversification (Figure 4) indicate that the *large moderator* states in our sample have significantly expanded their basket of production activities since the late 1960s.[10] Taken together, these observations suggest that the initial level of income and more generally the level of development might have contributed to the heterogenous moderation levels found in the data. We explore in more detail this hypothesis in the next section.

Before we leave this section, we briefly discuss the relation of our results with the existing literature. Regarding the link between initial large volatility and substantial moderation, Stock and Watson (2005) find that highly volatile countries tend to become smoother overtime. In particular, they use output data for the G7 countries to establish that countries with relatively high volatility in the 1970s were the less volatile in the 1990s. For instance, Italy and Japan, the most volatile countries prior to 1980, saw their post 1990s volatilities drop by 60% and 40%, respectively. On the other hand, Canada, the country with the smallest fluctuations in the 1970s, became more volatile by a factor of 1.2 after 1990.

More recently, Owyang, Piger, and Wall (2008) document the heterogeneity in the degree of moderation in employment across states in U.S. Although our study differs from theirs in

In a technical appendix available upon request, we show that implausibly large measurement errors are needed to account for such possibility.

[10]The economic diversification in Mississippi is nicely exemplified by the opening of factories to built aircraft engines (General Electric), cars (Toyota) and aerospace vehicles (Aurora Flight Sciences).

the data sources and econometric methodologies, we arrive at similar conclusions.[11] Indeed, we both find 1) a large decline in the volatilities of states like Arkansas and South Dakota, and 2) the Great Moderation has been less notable for California and New York. Finally, Carlino and Sill (2001) argue that heterogeneity is a pervasive feature in state data. Their study, however, did not establish a link between the heterogeneity in the volatility of state income and the Great Moderation.

3 Heterogeneity in Moderation and Development

As the previous section documents, not all states have benefitted equally from the moderation the aggregate economy has gone through. One interesting pattern that emerges from the structural break tests is that the states that display the greatest degree of moderation are the relatively poorer and less developed states, with low income levels and high initial volatilities. On the other end of the spectrum, the states that have experienced increases in the volatility of their growth rates are the relatively richer ones, all in the top quartile of the income distribution with low levels of initial volatilities. To illustrate the point further, we plot the degree of moderation, defined as the post-break to pre-break volatility ratio, for each of the states that exhibit a statistically significant structural break against their initial income. The relationship is plotted in Figure 4. Figure 4 depicts a positive correlation: low levels of income are associated with a smaller post-break to pre-break volatility ratio, hence a greater degree of moderation.

The relationship between risk, volatility and economic development has been the focus of many theoretical studies. The prominent examples include Greenwood and Jovanovic (1990), Saint-Paul (1992), Obstfeld (1994), and Acemoglu and Zilibotti (1997). Adopting a portfolio approach, all of these studies highlight the trade-off between investing in high risk-high return sectors and investing in relatively safe but low return sectors. In the absence of full-insurance of risks, producing in only in a few sectors, either due to scarcity of resources or due to comparative advantage considerations, implies higher variability of output. Therefore, diversification of production provides insurance, yielding to lower volatility of total output. As economies and/or

[11] They rely on Bayesian Markov Switching techniques to estimate the decline in volatilities.

financial markets develop, they start specializing again since gains from specializing in high return projects offset the welfare losses due of higher volatility. Saint-Paul (1992) shows how countries diversify for insurance purposes, and later they start to specialize as financial markets deepen. Greenwood and Jovanovic (1990) and Obstfeld (1994) focus on the role of financial intermediaries and international asset trading, respectively, in providing insurance to the investors, and allowing them to invest in high-yield projects without the volatility consequences. Similarly, Acemoglu and Zilibotti (1997) show that at early stages of development, countries specialize in safe but less productive projects/sectors due to indivisibility and minimum size requirement for each project. Diversification opportunities arise as countries accumulate more capital, allowing them to produce in more productive, albeit more risky, sectors in addition to the safer ones. The higher the number of sectors that are open, the easier it becomes to diversify idiosyncratic risk.

The negative relationship between output volatility and growth has been documented in numerous country-level studies (see e.g. Ramey and Ramey (1995) and Kose, Prasad, and Terrones (2006)). More recently, Koren and Tenreyro (2007) analyze the relationship between volatility and the level of economic development in a large panel of countries, and decompose aggregate volatility into its components. They find that the poor countries tend to specialize in fewer and more volatile sectors, and they experience more frequent and severe aggregate shocks. Furthermore, consistent with the findings in Imbs and Wacziarg (2003), they show that sectoral concentration first decreases and then later increases with economic development.

In this section we examine the relationship between the level of economic development and income volatility at the state level. We investigate whether the heterogeneity in the degree of moderation across states reflect the different stages of development process the states have gone through. As predicted by the aforementioned theories, the less developed states might have experienced greater reductions in their volatilities as a consequence of their development processes. On the other hand, the richer states might have experienced increases in their volatilities as they started to invest in high risk-high return sectors along their respective development processes. Therefore, the relationship between volatility and the level of development might be not be monotonic, and it might depend on the degree of diversification at the state level.

3.1 Empirical Specification and Data

In order to investigate whether the changes in volatility at the state level are associated with economic development and the degree of diversification/specialization, we estimate the following relationship:

$$\sigma_{it} = \upsilon_i + \eta_t + \beta_1 y_{it} + \beta_2 y_{it}^2 + \beta_3 h_{it} + \gamma X_{it} + \varepsilon_{it}, \tag{1}$$

where σ_{it} is the measure of real per capita income volatility in state i and year t, y_{it} is the logarithm of real per capita income, h_{it} is the measure of specialization, and X_{it} is a vector of other potential controls.[12] We allow for the non-monotonicity of the volatility-development relationship by including the quadratic income term, y_{it}^2. This term allows us to see whether volatility first decreases with the level of development, and then increases slightly back up as the states invest in high risk-high return sectors. We include fixed effects, υ_i, in our specification in order to control for time-invariant, state specific characteristics (such as the distance to the capitol or to the oceans), and time effects, η_t, in order to control for macro or policy shocks that are common to all states. Notice that, when we control for time and fixed effects, the remaining variation in income volatility is attributable only to time-varying state level factors. Therefore, we cannot directly assess the importance of some of the common theories offered to explain the Great Moderation, such as more effective national monetary policy.

In our estimations, and in constructing the income volatility and specialization measures, we use annual data due to the unavailability of detailed information on sectoral income and employment at the state level. We construct two income volatility measures: the first measure is the absolute value of the deviations of the growth rate of real per capita personal income away from the average growth rate for each state. Stock and Watson (2003) use the same measure but for aggregate variables. For the second measure, we estimate an AR(1) process for the growth rate of real per capita personal income in each state, and take the absolute value of the residuals

[12] We investigated the time series properties of the logarithm of real per capita income using the panel unit root tests developed by Levin and Lin (1993) and Im, Pesaran, and Shin (2003). When measured in the form of deviations from common year-specific means, the stationarity of real per capita income cannot be rejected with the respective p-values for the test statistics 0.000 and 0.007. Notice that inclusion of time effects in equation 1 eliminates the common trending components from y, and it is equivalent to subtracting the common year-specific means.

of those processes. The correlation between these two volatility measures is 0.91.[13]

The state level sectoral employment data come from the Bureau of Labor Statistics, and the series start in 1969. The Bureau of Labor Statistics reports employment in each sector based on the SIC classification until 2001, and based on the NAICS classification after 2001. Because there is no straightforward mapping between the two classification systems, we end our sample in 2001. Using the detailed information for each sector, we measure the degree of specialization in each state with the Herfindahl indexes of employment. We construct the Herfindahl indexes by adding up the sum of squared employment shares (see Table 4 for the list of sectors). The theories suggest that at the earlier stages of development, economies diversify, and as they become more developed they start to specialize in more productive sectors. Accordingly, we would expect diversification to contribute to the reductions in volatility.[14] We further use employment shares of various major sectors to capture the labor force composition of each state and include them as additional controls. The labor force composition allows us to control for the importance of endowment sectors (agriculture and mining) relative to more advanced sectors such as manufacturing and services.

Another set of controls includes measures of bank integration constructed by Morgan, Rime, and Strahan (2004). They show that fluctuation in a state's economic growth falls as banks get more integrated. We include the same bank integration measures in order to check whether the relationship between development and volatility holds when we also control for bank integration. The four bank integration measures we use are: dummy variables for the deregulation of interstate banking and interstate branching, and two continuous measures for capturing the degree of integration. The first one, is the *interstate asset ratio*, which equals the fraction of bank assets in a given state that are owned by a holding company that owns assets in other states. The second measure is the *other state asset ratio*, which is the ratio of total out-of-state assets held by holding companies in state i to total assets in state i. The interstate asset and other state asset ratios are available only for the 1976-1994 subsample. Detailed information about these variables can be found in Morgan, Rime, and Strahan (2004).

[13] See the previous section for the construction of real per capita personal income.

[14] The Herfindahl measure lies between 0 and 1, with 1 corresponding to full-specialization. Diversification implies a reduction in the Herfindahl measure; therefore the expected sign for the Herfindahl in our regression is positive.

3.2 Results

Table 2 presents the Instrumental Variables estimates of equation (1) for the 48 contiguous states. In the first two columns volatility is measured as the absolute value of deviations from the mean growth rate of each state, and in the last two columns it is measured as the residual from the AR(1) specification for the growth rate of personal income. The estimates obtained using the two different volatility measures are quantitatively very similar. In all of the specifications we treat income and specialization as endogenous variables. As instruments, we use appropriate lags of the regressors and two lags of population growth rate of each state. The exact list of instruments can be found at the end of each table.[15] All four specifications in Table 2 are supported by the tests of over-identifying restrictions, for which the Sargan-Hansen test statistics fail to reject the validity of the instrument sets, and by the Kleibergen and Paap (2006) tests of under-identification, for which the null hypotheses of under-identification are strongly rejected.

We start by presenting the results for the baseline specification, which includes income and income-squared only, and then proceed by including Herfindahl index, to capture the impact of diversification. In all four of the specifications the lagged income variables are highly significant. The results in Table 2 show that there is a statistically significant non-monotonic relationship between the level of income and volatility in the US. While volatility initially decreases with income, it increases at later stages of development. Intuitively, this result suggests that the states in the *large moderator* group experienced a decline in volatility as their income levels increased and as they got economically more developed. Furthermore, the *non-moderators* did not benefit from the moderation as they were already in an advanced stage of development levels. This is consistent with the theoretical studies that predict that at early stages of development, economies will diversify production and obtain reductions in volatility. At later stages of development, however, they can invest in high risk-high return projects, which would allow them to achieve higher productivity at the cost of increased volatility.

Next, we include the Herfindahl index in our baseline specification in order to evaluate the impact of diversification on the volatilities. The Herfindahl index is positive and highly significant in both of the specifications. This suggests that the diversification of production

[15] The exact list of instruments were chosen based on the Kleibergen and Paap (2006) test of under-identification and Sargan-Hansen test for instrument validity.

along the states' development processes, measured by a decrease in the Herfindahl index, has also contributed to the reduction in their volatilities. The estimates in columns (2) and (4) imply that, on average, a 1% increase in diversification (a 1% reduction in the Herfindahl), would decrease income volatility by 2.79% and 3.51%, respectively.[16] To analyze this implication further, we plot the Herfindahl indexes for the large moderator and large non-moderator states identified in the previous section. As shown in the first panel of Figure 5, the states that have gone through the largest degree of moderation have gone through major diversification. Mississippi, Montana, North and South Dakota seem to have diversified their production base consistently since the beginning of the 1970s. While the Herfindahl fluctuates a lot for Arkansas, it is on average lower towards the end of the sample. Interestingly, three out of five large non-moderator states–Massachusetts, New Jersey and New York– exhibit increases in their Herfindahl indexes, showing slightly higher degree of specialization starting in the early 1980s. Our estimates of the Herfindahl index suggests that the increase in degree of specialization in these states has contributed to higher income growth volatility.

In order to check the robustness of our results to the inclusion of additional variables that have been previously looked at in the literature, we include employment shares of five major sectors, and the bank integration measures.[17] Since the two volatility measures give us very similar results, we present results using the volatility measure constructed with the deviations from the mean. Similar to the previous specifications, we treat the additional control variables as endogenous and instrument them. The first column of Table 3 presents the results with the employment shares of agriculture, mining, durable and non-durable manufacturing and services sectors. In their decomposition, Koren and Tenreyro (2007) find that agriculture and mining are more volatile than manufacturing, which is in turn more volatile than services. Based on their finding, we would expect states with larger agriculture and mining sectors to be more volatile

[16]The elasticities of the volatility measures with respect to the Herfindahl index are calculated at the sample means. The means for the two volatility measures are 0.0187 (deviations from the mean measure) and 0.0187 (AR(1) residuals measure). The sample mean for the Herfindahl index is 0.0880.

[17]Another interesting variable that has been looked at in the literature is age composition of the labor force. Jaimovich and Siu (2009) document the link between age composition of the labor force and the business cycle volatility in G7 economies. Specifically, they find that the share of 15-29 year olds plus 60-64 year olds (the "volatile-age" groups) in total labor force is positively associated with increased business cycle volatility. Even though it would be very interesting to replicate their study for the US states, the lack of data on detailed age groups for the 1970-2001 sample prohibits us from investigating this channel.

and states with larger services sector to be less volatile. We find a significant impact of the services sector only, while income variables and the Herfindahl index are still significant. Since the Herfindahl index measures the extent of diversification by capturing the concentration of employment shares in the various sectors, employment shares might not be providing additional information in this setup. When we exclude the Herfindahl index from this specification, the shares of durable manufacturing and services become negative and significant. The negative and significant impact of durable-goods share is also found in Owyang, Piger, and Wall (2008), who interpret the result as an evidence for volatility reductions due to innovations in durable-goods' inventory management. As expected, higher share of employment in services is associated with a lower income volatility. Additionally, the estimates imply that a higher share of agriculture in total employment is associated with higher volatility, although the share of agriculture is only marginally significant (the corresponding p-value is 0.106).

Finally, we investigate the impact of banking deregulation on income volatility. Columns (2) and (3) of Table 3, display the results with interstate-banking and interstate-branching deregulation indicators, respectively, and column four displays the results with the interstate and other state asset ratios. Out of these four measures, only the interstate asset ratio is estimated significantly, and the other main variables of interest remain significant. As in Morgan, Rime, and Strahan (2004), the negative coefficients imply that increased bank capital mobility is associated with lower income volatility.[18] In all these new specifications, our measures of development and specialization remain statistically significant, which further confirms our conjecture that they are essential factors in understanding the substantial heterogeneity in the degree of moderation across the states.

4 Conclusion

State level data can be a fruitful source of information about economic volatility and its determinants. The states are a free trade area without legal restrictions on the mobility of labor and capital. They have common monetary, exchange rate, and federal fiscal policies. The states have

[18] Morgan, Rime, and Strahan (2004) use a slightly different volatility measure and find negative and significant impacts of both the inter-state and other-state assets ratios on volatility for 50 states.

a common language and similar institutions, but they also have significant differences related to their economic development. Variation in income per capita, the degree of specialization, and the structure of production are significant determinants of income volatility across states.

Most states have experienced a reduction in the volatility of income. However, there has been heterogeneity in the magnitude and timing of moderation. The greatest reduction in volatility has occurred in the lowest income states, such as South Dakota, Mississippi, and Arkansas. Less moderation occurred in high income states, including 10 mostly affluent states that experienced a significant increase in volatility.

Our empirical results demonstrate a consistent relationship between volatility and economic development. We found a robust relationship between a state's volatility and its income per capita and degree of specialization. From low levels of income, growth decreases volatility, but at higher income levels growth increases volatility. Increases in specialization contribute to an increase in volatility. Expansion of the service sector and expansion of interstate banking reduce volatility. There is some evidence that the decline in the share of durable manufacturing contributed to lower volatility.

In summary, our results complement the literature on country-level moderation. We cannot directly address the question of how changes in monetary policy and/or national shocks might have affected volatility. However, we have shown that variables related to economic development are consistently related to the volatility of income across states.

5 Appendix

5.1 Dating the Moderation

Let $\Delta y_t \equiv \log(y_t/y_{t-4})$ denote annual per capital real income growth in period t. Then timing the structural break, as implemented in McConnell and Perez-Quiros (2001), consists on the following steps:

1. Using GMM, estimate an AR(1) process for the growth rate of income:

$$\Delta y_t = \phi \Delta y_{t-1} + \varepsilon_t,$$

and the following process for the estimator of the standard deviation of ε_t:

$$\sqrt{\frac{\pi}{2}}\,|\widehat{\varepsilon}_t| = \alpha_1 D_{1,t} + \alpha_2 D_{2,t} + \vartheta_t,$$

where ϑ_t is white noise, and the dummy variables $D_{i,t}$ are defined as

$$D_{1,t} = \begin{cases} 0 \text{ if } t < \widetilde{t} \\ 1 \text{ if } t \geq \widetilde{t} \end{cases} \text{ and } D_{2,t} = \begin{cases} 1 \text{ if } t < \widetilde{t} \\ 0 \text{ if } t \geq \widetilde{t} \end{cases}.$$

Here T corresponds to the period we suspect the break in variances happened. As in McConnell and Perez-Quiros, we use a constant Δq_{t-1}, $D_{1,t}$, and $D_{2,t}$ as the instruments for the regression.

2. Since the break is unknown the steps 1 and 2 are repeated for $\widetilde{t} \in [0.15T, 0.85T]$, which is a customary choice in applied econometrics (Hall, 2005). Here T corresponds to the sample size. Our choice implies that the potential break point lies between 1967.1 and 1995.4.

3. The null hypothesis of the test is $\alpha_1 = \alpha_2$, i.e. no structural break in the volatility of the time series. There is one Wald statistics, $W\left(\widetilde{t}\right)$, of the null hypothesis for each potential break point. We select the most likely date for the start of the moderation as the $\widetilde{t}$ with the highest Wald statistic (Andrew (1993)). The significance of the test is determined using the results reported in Hansen (1997).

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Figure 1: Personal Income Volatility Ratios

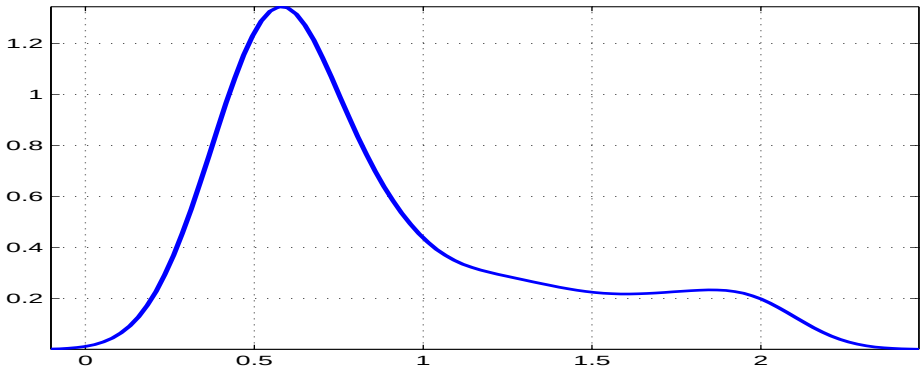

Figure 2: Kernel Density of Break Dates

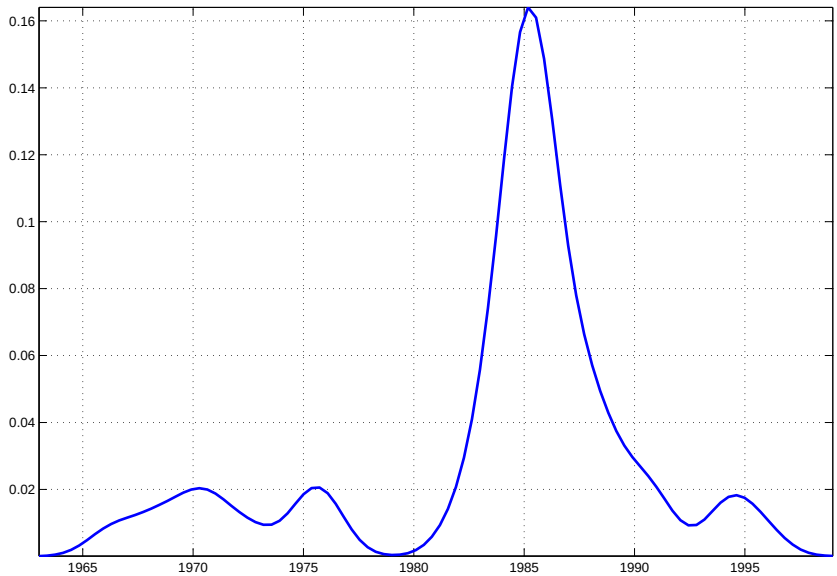

Figure 3: 10 Year Rolling Volatilities for the Largest Moderators and Largest Non-Moderators

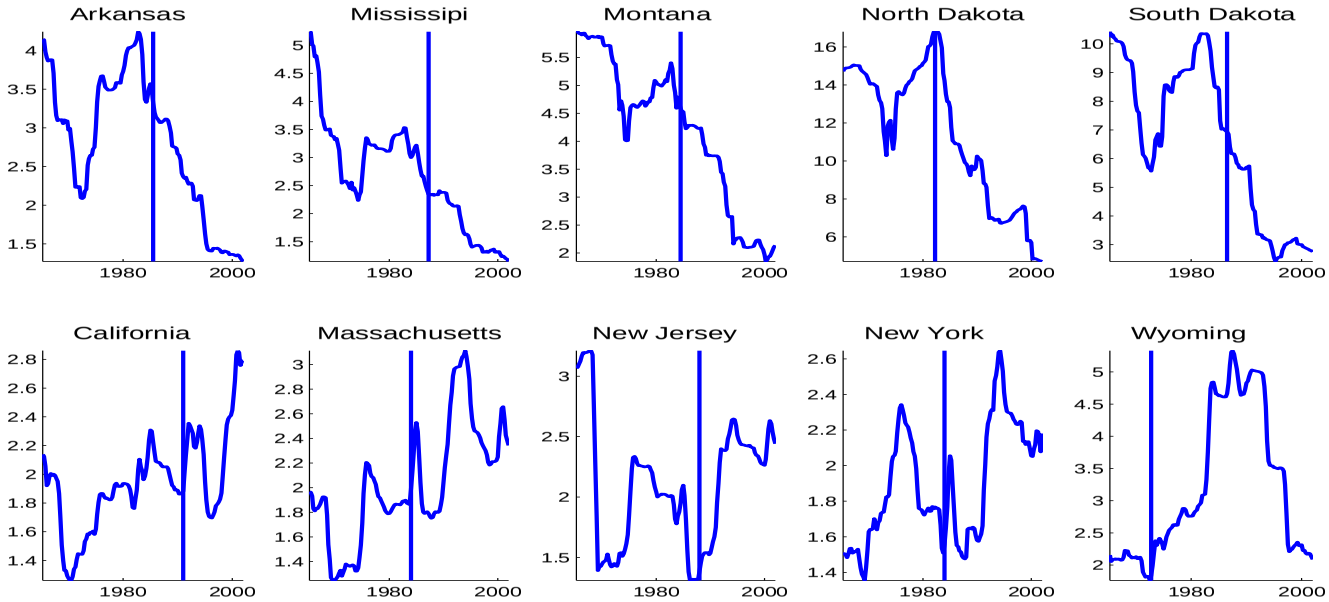

Figure 4: Degree of Moderation and Initial Income

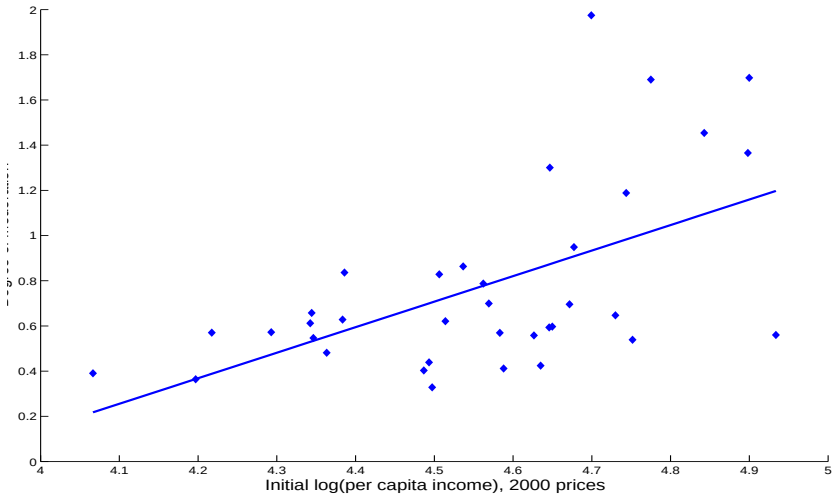

Figure 5: Diversification in the Large Moderator and Large Non- Moderator Groups

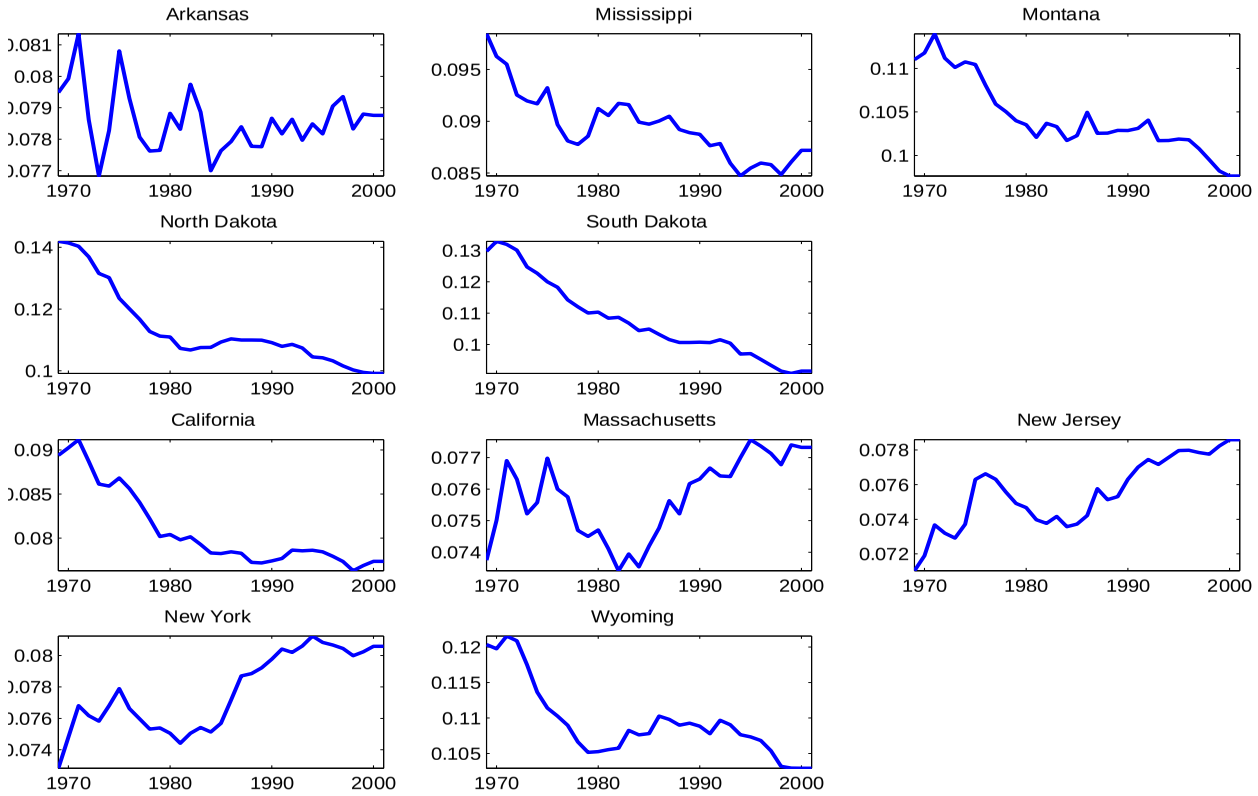

Table 1: Great Moderation in the U.S. States

	$\frac{\sigma_{\text{post-break}}}{\sigma_{\text{pre-break}}}$	Date Break	Initial Income		$\frac{\sigma_{\text{post-break}}}{\sigma_{\text{pre-break}}}$	Date Break	Initial Income
U.S.	0.87	1984.IV	10,782	Nebraska	0.42	1985.I*	10,302
Alabama	0.57	1985.I*	7,318	Nevada	0.56	1983.III*	13,889
Arizona	2.03	1967.IV	9,811	New Hampshire	1.30	1983.III*	10,424
Arkansas	0.36	1984.IV*	6,648	New Jersey	1.45	1987.III*	12,681
California	1.69	1990.II*	13,427	New Mexico	0.71	1987.III	9,000
Colorado	1.54	1970.I	11,093	New York	1.36	1983.III*	13,405
Connecticut	1.93	1966.I*	13,293	North Carolina	0.66	1985.I*	7,704
Delaware	1.01	1988.II*	13,379	North Dakota	0.40	1981.IV*	8,883
Florida	0.79	1974.IV*	9,580	Ohio	0.64	1985.I*	11,330
Georgia	0.63	1985.II*	8,012	Oklahoma	0.62	1987.IV*	9,129
Idaho	0.44	1982.IV*	8,941	Oregon	0.63	1985.I	10,783
Illinois	1.17	1990.IV	12,696	Pennsylvania	0.90	1985.I	10,896
Indiana	0.59	1984.IV*	10,457	Rhode Island	0.95	1975.III*	10,748
Iowa	0.57	1984.IV*	9,783	South Carolina	0.57	1985.I*	6,786
Kansas	0.56	1984.IV*	10,215	South Dakota	0.33	1986.I*	8,977
Kentucky	0.61	1986.II*	7,689	Tennesse	0.55	1985.I*	7,720
Louisiana	0.84	1986.II*	8,031	Texas	0.86	1986.IV*	9,338
Maine	0.46	1994.I*	9,033	Utah	0.70	1988.IV*	9,646
Maryland	1.12	1989.III	11,161	Vermont	0.61	1994.I*	9,084
Massachusettes	1.69	1983.III*	11,851	Virginia	0.83	1975.IV*	9,058
Michigan	0.54	1985.IV*	11,578	Washington	1.19	1995.III*	11,485
Minnesota	1.83	1970.III*	10,171	West Virginia	0.48	1984.III*	7,852
Mississippi	0.39	1986.IV*	5,835	Wisconsin	0.70	1984.IV*	10,687
Missouri	0.59	1985.II*	10,416	Wyoming	1.97	1972.II*	10,987
Montana	0.41	1984.I*	9,830				

Notes: Initial income is the per capita personal income in 1960 (in 2000 prices).
Break dates are determined using McDowell and Perez Quiros' (2000) approach. A star indicates that the equality of pre- and post-moderation volatilities is rejected at 5

Table 2: Personal Income Volatility and Development Estimates for the States

	(1)	(2)	(3)	(4)
Dependent variable : Volatility of real per capita income, σ_{it}	*Deviations from the mean*		*AR*(1) *residuals*	
Income (y_{it})	-0.4468***	-0.4694***	-0.3891***	-0.4332***
	(0.0700)	(0.1199)	(0.0692)	(0.1267)
$Income - squared\ (y_{it}^2)$	0.0255***	0.0269***	0.0232***	0.0253***
	(0.0037)	(0.0059)	(0.0037)	(0.0061)
$Herfindahl\ (h_{it})$		0.5920**		0.7265***
		(0.2383)		(0.2495)
$Kleibergen - Paap\ test\ of\ under - identification$	0.0000	0.0000	0.0000	0.0000
$Test\ of\ over - identifying\ restrictions$	0.8531	0.7796	0.5953	0.1214
Number of observations	1872	1488	1872	1488

Notes: Reported results are the IV estimates with heteroscedasticity and autocorrelation consistent robust standard errors. The instrument set consists of second lags of income and income squared and lags 1 and 2 of population growth rate in columns (1) and (3). In columns (2) and (4), the instrument set also includes second lag of the Herfindahl index.
The estimations include year and fixed effects.
*, ** and *** denote significance at 10%, 5% and 1%, respectively.
The p-values for the Kleibergen-Paap test of under-identification and the Sargan-Hansen test of over-identifying restrictions are reported.

Table 3: Personal Income Volatility and Development Estimates for the States, Additional Controls

Dependent variable : Volatility of real per capita income, σ_{it}	(1)	(2)	(3)	(4)	(5)
Income (y_{it})	-0.7946***	-0.7193***	-0.4690***	-0.4515***	-0.6517*
	(0.2374)	(0.2227)	(0.1200)	(0.1196)	(0.3614)
Income − squared (y_{it}^2)	0.0442***	0.0402***	0.0269***	0.0259***	0.0394**
	(0.0118)	(0.0110)	(0.0108)	(0.0059)	(0.0174)
Herfindahl (h_{it})	0.6204*		0.5915**	0.6383***	0.8030*
	(0.3379)		(0.2383)	(0.2467)	(0.4853)
Share of agriculture in total employment	0.9629	1.0276			
	(0.6136)	(0.6366)			
Share of mining in total employment	-0.1412	-0.2318			
	(0.1506)	(0.1484)			
Share of durable manufacturing in total employment	0.0185	-0.1351**			
	(0.0802)	(0.0577)			
Share of nondurable manufacturing in total employment	-0.0252	-0.0938			
	(0.0547)	(0.0726)			
Share of services in total employment	-0.0906*	-0.1222**			
	(0.0530)	(0.0614)			
Interstate − banking			-0.0001		
			(0.0022)		
Interstate − branching				-0.0023	
				(0.0015)	
Interstate asset ratio					-0.0317**
					(0.0151)
Other state asset ratio					0.0004
					(0.0011)
Kleibergen − Paap test of under − identification	0.0000	0.0000	0.0000	0.0000	0.0004
Test of over − identifying restrictions	0.8235	0.4739	0.7751	0.8079	0.2047
Number of observations	1488	1488	1488	1488	874

Notes: Reported results are the IV estimates with heteroscedasticity and autocorrelation consistent robust standard errors when volatility is measured as the absolute value of the deviations from the mean.
In columns (1), (2) and (4) second lags of the employment shares are included in the instrument set in addition to the one listed in Table 2, in order to achieve identification. The estimations include year and fixed effects.
*, ** and *** denote significance at 10%, 5% and 1%, respectively.
The p-values for the Kleibergen-Paap test of under-identification and the Sargan-Hansen test of over-identifying restrictions are reported.

Table 4: Sectors (SIC Classification)

Agriculture, forestry and fishing	Paper products, printing and publishing
Mining	Transportation
Construction	Utilities
Wood, lumber and furniture manufacturing	Communication
Leather products manufacturing	Wholesale trade
Stone, clay and glass manufacturing	Retail trade
Primary and fabricated metals manufacturing	Finance, Insurance and Real Estate
Industrial and electronic machinery and equipment	Hotel, lodging and entertainment services
Motor vehicles and other transport equipment	Personal services
Instruments and related manufacturing	Business services
Miscellaneous manufacturing	Auto and miscellaneous repair services
Food and kindred products manufacturing	Health Services
Tobacco products manufacturing	Legal services
Textile mill products and apparel manufacturing	Educational services
Chemicals manufacturing	Other services
Petroleum products manufacturing	Government
Rubber and plastic manufacturing	

Notes: The Herfindahl index is constructed as the sum of squared employment shares of each of these sectors.